CLIMATE EFFECTS ON BIODIVERSITY, ABUNDANCE AND DISTRIBUTION OF MARINE ORGANISMS – AN OVERVIEW OF THE NansClim PROJECT

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Climate change is defined as a long-term trend in climate development due to anthropogenic influences. In addition, there is natural variability at seasonal, interannual, decadal and multi-decadal scales. There has been a general warming of a large part of the world oceans during the past 50 years [1] and while there are regional differences, in southern Africa a long-term increase of 0.25°C in sea surface temperature has been observed during the last four decades [2]. A recent report from the World Bank states that "overfishing plus climate change means severe depletion of the world's fishery resources, with about half of current gross revenues predicted to be lost under severe climate change scenarios" [3]. The report further states that "adapting fisheries to climate change will not be cheap, especially for developing countries, many of whom lack adaptive capacity".

The NansClim Project (Climate effects on biodiversity, abundance and distribution of marine organisms) is therefore timely. Its primary goal and objectives are to identify, describe and clarify possible trends and variability in ocean climate and corresponding changes in marine biodiversity and fisheries that have been observed in the Benguela Current ecosystem over the past decades.

The project focuses on analysis and dissemination of oceanographic biodiversity data collected in the region through the Nansen Programme surveys combined with other relevant data collected and made available primarily by local national research institutions in the region. This will allow scientists to predict general responses in respect of production and distribution of marine biota in order to set a baseline of observed effects of climate variability. As such, the objectives of NansClim subscribe to the vision of the recently launched Nansen-Tutu Centre for Marine Environmental Research, which is "… to serve Africa through advancing the knowledge of the marine environment and climate system by improving the capacity to observe, understand and predict the variability of the marine ecosystem on time scales from days to decades".

Forecasting regional climate change and detection of its effects on marine biodiversity in the Benguela Current system have in the past been a key objective of two regional research and capacity building programmes, BENEFIT (Benguela Environment Fisheries Interaction and Training [4]), initiated in 1997 and BCLME (Benguela Current Large Marine Ecosystem [5]), initiated in 2003; both came to an end in 2007. A natural extension of these programmes was the establishment in 2008 of the Benguela Current Commission (BCC), a multi-sectoral initiative by Angola, Namibia and South Africa to promote integrated management, sustainable development and protection of the environment using an ecosystem approach to ocean governance. Studies of climate effects on the Benguela ecosystem form a major component of the Science Plan of the BCC, as well as that of the newly formed Branch: Oceans and Coasts of the national Department of Environmental Affairs in South Africa.

The project is further closely linked to, and complements the ongoing EAF Nansen Programme, which was implemented by FAO and has a component related to developing indicators of ecosystem change, albeit based on reviews and desktop studies of existing knowledge. In addition, NansClim complements ongoing research on ecosystem change conducted by the EAF Group of the Marine Research Institute of the University of Cape Town, and will benefit from close cooperation with NansClim in terms of data sharing and joint analysis.

The expected outcomes of the NansClim Project are:

- A coordinated database system for physical and biological data;
- Suggestions for marine Ecosystem Indicators;
- A better understanding of the effects of climate change and variability on the marine ecosystem in the Benguela Current region;
- Possible implications of climate change on fisheries and other marine activities;
- Future scenarios of climate effects on marine resources;
- Strengthened regional cooperation;
- Regional competence building on ecosystem effects of climate change;
- Increased public awareness of climate change in relation to fisheries and the marine environment.

The NansClim Project comprises four Modules, through which the project's objectives will be achieved:

- Module 1: Coordination of the Nansen database and other regional data;
- Module 2: Climate variability and climate impact on the marine ecosystem;
- Module 3: Gaps in our knowledge and research needs to address them;
- Module 4: Project management.

Activities of Module 1 are focused on two main tasks; firstly, on the selection and collation of data gathered during surveys onboard the RV *Dr. Fridtjof Nansen* during the Nansen Programme (1985 onward), and secondly, on the linking of this Nansen database to supplementary data. The latter have been collected during a myriad of surveys conducted primarily by the fisheries research agencies of the governments of Angola, Namibia and South Africa, as well as regional (BCC) and international partners working in the region (e.g. GENUS). Only time-series of quality-controlled data that are relevant in a climate-change context will be considered. They include satellite data and *in situ* data on meteorology, physical, chemical and biological oceanography, crustaceans and fish, and some of these time-series go back in time to the early and mid 1900s.

There are three tasks addressing the objectives of Module 2, viz. (i) Climate Variability and Change, (ii) Responses of the Pelagic Ecosystem to Climate Change, and (iii) Climate Effects on the Biodiversity of the Demersal Community. Each of these tasks aims at answering a set of specific key questions. The Task Group on 'Climate Variability and Change' aims to identify climate events that have been observed and might have an impact on the marine ecosystem. In order to separate short-term events from long-term trends over the past 50-100 years, a combined time-series analysis approach of fine-scale temporal resolution satellite imagery (to detect trends) and coarser-scale *in situ* environmental data (to detect events and serve as ground-truthing) will be adopted. Analyses will be done for representative sub-regions of the Benguela ecosystem. The focus is on temporal changes in water mass structure, water column stratification and stability, and concentration of dissolved oxygen, as well as variations in intensity, timing and duration of primary physical forcings, including coastal upwelling and remotely forced poleward water intrusions of Angola Current origin.

The Task Group on 'Responses of the Pelagic Ecosystem to Climate Change' aims to investigate major trends in the biomass and certain population parameters of key pelagic species – including phytoplankton, zooplankton, jellyfish, small pelagic fish, mesopelagic fish, and their predators – and whether these trends are related to climate change indicators. Major distributional shifts of populations will also be examined. Moreover, changes in the location and extent of areas that are critical in the life cycle of species, such as spawning and nursery areas, and their likely causes will be investigated. Finally, direct and indirect impacts of climate on pelagic species will be identified.

In principle, the aims of the Task Group on 'Climate Effects on the Biodiversity of the Demersal Community' are formulated along the same lines, however with a focus on the demersal species assemblages (including fish, crustaceans and cephalopods) where latitude, depth, temperature and dissolved oxygen may affect community structure and distributional shifts.

Following a comprehensive regional data audit, work is currently underway reconstructing up-to-date multi-decadal time-series of environmental indicators and pelagic and demersal key indicator species, which will be analysed using an array of appropriate

statistical analysis and modelling tools; indicators related to distribution and behaviour of species are also being developed. As a result from these analyses, a list of environmental and biological indicators for climate change will be assembled.

While it is recognized that presently only some qualitative answers can be provided to questions regarding climate change, it is appreciated that it is unlikely to account for non-linear effects or multi-species interactions. As a consequence, reliable quantitative information on the response of the Benguela ecosystem to climate change is lacking. A key challenge for the project will therefore be to conduct a comprehensive gaps analysis of knowledge gained during the first part of the project and to suggest research needs and actions to fill these gaps, which forms the object of Module 3.

Project management falls under Module 4. NansClim is a partnership of the Instituto Nacional Investigação Pesqueira (INIP) of the Ministério das Pescas of Angola, the National Marine Information and Research Centre (NatMIRC) of the Ministry of Fisheries and Marine Resources of Namibia, the Branch: Oceans and Coasts of the Department of Environmental Affairs (DEA) and the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF) of South Africa, and the Institute of Marine Research (IMR) of Norway, who is also the project's executing agency. The project is funded by Norad, the Norwegian Agency for Development Cooperation, with in-kind contributions from the governments of the three countries bordering the Benguela Current ecosystem.

The project is coordinated by the IMR, who also chairs the Project Management Committee (PMC), made up of two representatives from each of the partner countries and an observer from the BCC. The PMC is responsible for developing work plans and coherent budgets, monitoring progress, stimulate publication of results, organize meetings and workshops, and compile annual progress reports and financial statements. An Advisory Panel has been established to assist with the implementation of and act as supervisors to the project. They provide scientific guidance to the management team, assess the quality of reports and scientific papers that emanate from the project, and may participate in project meetings and contribute to scientific papers where appropriate.

The success of the project relies heavily on close collaboration between scientists from the four partner countries. Therefore, the project facilitates exchange of scientists between these countries to meet regularly in order to collaborate in regional workshops, symposia and the writing of publications. Provision is also made in the project's budget for regional competence building, at post-graduate levels (MSc and PhD), in respect of ecosystem effects of climate change.

Thus far, six workshops have been held in Norway and Namibia, addressing some of the tasks of Modules 1 and 2. A number of scientific papers are already in different stages of publication, and several have been presented and discussed at the project's mid-term progress meeting that was held in Stellenbosch, South Africa in March 2011.

Dissemination of results from the project to the scientific community, the governments of Angola, Namibia and South Africa, their environmental and fisheries managers, as well as fishing communities and the general public is regarded an important aspect of the NansClim Project. For instance, the project already enjoyed much exposure at various outreach activities that were organized at the occasion of World Ocean Day celebrations in Angola, Namibia and South Africa on 8 June 2010. Publications will include scientific articles in peer-reviewed journals, presentations at conferences and symposia, and reports in popular science magazines and newspapers. To that extent, writing groups for each of the scientific tasks mentioned above have been established early in the project, securing momentum in the production of publications from the onset of the project.

The NansClim Project is planned to run for three years (end 2009-end 2012), after which it will be evaluated. It is expected that, through an assessment of the consolidated database (Module 1) and a gaps analysis (Module 3), new research priorities will emerge, which will not be possible to be addressed within this given timeframe. As a consequence, consideration of an extension of the project may be necessary. In addition, the possibility of extending the project to other regions where the Nansen Programme has operated should also not be discounted.

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